CHAPTER 4

 OCCURRENCE AND MOVEMENTS OF GROUNDWATER
4. OCCURRENCE AND MOVEMENTS OF GROUND WATER

The groundwater resources are highly influenced by the geomorphic and geological set-up of the region. The physical properties of rocks influence and control water bearing and yielding capabilities (Jagatheesan, 1988). The mode of groundwater occurrence of the basin under investigation have been carried out with the help of existing topography, rainfall pattern and on the nature of geological formations in respect to its water bearing and yielding capacities, e.g. porosity, permeability etc.

4.1 HYDROGEOLOGICAL CONDITIONS OF LITHO-UNITS:

In the study area, the water holding formation mainly comprises of calcareous and argillaceous sequence of Raipur Group, laterities, and Alluvium. The calcareous rocks consist of purple limestone and grey dolomitic limestone with shaley intercalations. The limestones are predominantly stromatolitic and typically karstic in nature and vary widely in density, porosity and permeability, depending upon the degree of consolidation and development of permeable zones after deposition (Adyalkar and Phadtare, 1972; Adyalkar and Ramanna, 1973; Phadtare and Ramanna 1969-72).

4.1.1 Stromatolitic limestone: Stromatolitic limestones in the area form the potential aquifers. They are hard, dense and well
indurated possessing little primary permeability. However, secondary porosity has been developed due to creation of a large number of voids, cavities and fractures (Adyalkar et al. 1975; Adyalkar, 1976) and groundwater occurs in them under confined and un-confined condition. The limestone shows secondary permeability and porosity due to dissolution effect along joints and fractures (Adyalkar and Ramanna, 1980; Ford and Williams; 1989). The excessive solutional features and sinking of surface waters in the formation indicates high secondary permeability, which is attributed mainly to the effect of chemical weathering and partly to fracture porosity. The weathered zone, bedding planes and joints constitute the water table aquifer in the study area. Presence of karst features and joints allow free circulation of groundwater in the area. The weathered zone and bedding planes of limestones with intercalated purple shales form the water table aquifer, which is tapped by open wells in the study area (Fig. 4.1).

The prominent karst features present in the area of dolines, swallow holes, grikes and clints of various sizes and dimensions. These karstic land forms are best exposed in the Nipania member of Chandi formation and are observed around nala sections close to Khapri (Neora) and Jangra villages (Fig. 4.2, 4.3) and also around Gorhi, Bhatapara, Turma and Alesur villages. At places, where surface waters flow through joints in the limestones enlarging the gap between jointed blocks, the typical karstic features i.e. limestone pavements are developed (Fig. 4.4). The solution openings are more common so as to form a
Fig. 4.1: An openwell in the purple limestone with intercalated shales covered by weathered zone (lined with bricks) near Tohra village.

Fig. 4.2: Karstifications (Dolines and Swallow holes) in purple limestone exposed in the Jamunia nala at Khapri village (Tilda).
Fig. 4.3: Grike and Clints developed in Raipur purple limestone near Jangra village.

Fig. 4.4: Limestone pavement developed in Raipur limestone due to Karstification along joints near Khapri village (Tilda).
network of interconnected cavities which act as conduits for free movement of groundwater and provides larger yields.

4.1.2 Dolomitic limestone: Dolomitic limestone is a principal aquifer in the area which occurs as pockets or irregular bodies of varying sizes and dimensions ranging from a few meters to tens of kilometers and are often associated with shaley-intercalations (Adyalkar and Dube, 1978). It is a massive, compact and is comparatively less karstic in nature. Though the solution features have developed during the dolomitisation of limestones.

These features have induced secondary porosity and permeability which act as promising aquifers for groundwater development in the area.

The dolomitic limestone occurring around Kumhari, Hirmi, Pendri, Chandi and Kuthraud villages is massive and less karstic in behaviour. As such, the formation may contain water in weathered zones only and provide limited scope for percolation at shallow depths where groundwater occurs under unconfined conditions above the water table. Thus, in the area around Kathia, Kumhari, Kuthraud and Pendri villages, the dugwell failure has been observed. However, since the area is bounded by artificial canal system, the local demand of water can be fulfilled to some extent.

4.1.3 Laterite: Laterite occurs as capping over all rock formations of the area under study (Fig. 4.5). It is associated
Fig. 4.5: Lateritic capping associated with calcareous formations at Urela village.
with calc-argillite formation with thickness varying from 0.5m to 10m. Laterites are permeable and porous, so rapid input and output flow conditions exists in the area.

4.1.4 Alluvium: The alluvium is composed of the weathered materials of shale, limestone and lateritic formation of the area. The equigranular nature of the finer particles increase the rate of porosity and permeability. Thus, the alluvium formations contain sufficient quantities of water for exploitation. Its thickness in the Jamunia river basin has been observed to be approximately of 3 to 6m.

4.2 WELL-INVENTORY:

In order to understand the general nature of the groundwater occurrence and movement, detailed well inventory of 150 open wells, spread over the entire basin, have been undertaken for pre-monsoon and post-monsoon periods i.e. April-May, 1992 and Oct-Nov. 1992, respectively.

The well inventoried data, e.g. well diameter, and its total depth, depth to water level, static water level for pre-and post-monsoon periods were collected (Appendix-2) to determine the area of potential recharge, and direction of movement of groundwater. The Reduced level (RL) of wells with reference to M.S.L. were determined. These were processed on computer software programming system and used to prepare surface relief map (Fig. 1.6), water level maps, and depth to water level maps for pre-and post-monsoon seasons and the fluctuation map, on 1:50,000 scale.
FIG 46 SURFACE RELIEF MAP OF JAMUNIA RIVER BASIN.
4.3 GROUNDWATER CONTOUR MAP:

The study of groundwater contour map is very useful to estimate the hydrogeologic characters of the water bearing formations and topography of the region. For this purpose, the water level contours have been constructed from well inventory measurements. The contours with interval of 4m have been drawn, because it was not possible to accommodate large number of contour lines in a narrow and linear shaped basin. On the basis of these maps, the interpretations and inter-relationships between various geomorphic features and groundwater conditions have been made to decipher the hydraulic conductivity of an aquifer.

4.3.1 Premonsoon: It has been observed for the Jamunia river basin, that the general trend of the groundwater flow is almost uniform in both pre-and post-monsoon periods (Fig. 4.7). The important features are summarised as follows:

1. The contour map shows that the general hydraulic gradient is towards northeast, i.e. along the flow direction of the nala and rivers.

2. The altitude of water level contours ranges from 232m to 292m above M.S.L. The water level contour, the highest near Chicholi village lies at a height of 292m above M.S.L. WHEREAS TOWARDS THE Sonadih village it is lowest (232m).

3. The overall pattern of contours indicates that the entire Jamunia drainage network is of effluent in nature, as the streams receive water from the surrounding areas.
4. In general, contours in the southwestern part of the basin are closely spaced around Chicholi, Tarasheo, Kathia, Kumhari, Bhimbhori, Tilda and Neora villages indicating low hydraulic conductivity of the formation.

5. Rest of the portion is occupied by wider contour spacings revealing zones of higher hydraulic conductivities. Such variations in the hydraulic conductivities, observed in the limestone formations, might be attributed to the irregular disposition of water bearing formations as well as weathering conditions and degree of secondary openings which control the movement of groundwater.

6. The changes in contour spacing may be indicative of changes in aquifer conditions, as apparent in the middle portion (near Suhela, Bortara, Semaria and Rawan villages) of the basin. Such changes in limestones of Raipur Group are caused by the lateral variations and non-homogeneous nature.

7. In general, the area exhibits the movement of groundwater in northeasterly direction (Fig. 4.7). In southeastern part of the basin the direction of flow is due north wards and its movement concoides with the surface topography of the region.

8. The hydraulic gradient estimated from the water level contour map ranges from 2.5 to 4.5m/km which is moderate to gentle indicating permeable nature of formation.

9. Small groundwater mounds (Fig. 4.7) have been observed near Chicholi and Tilda villages in the southern and near Sonadih village in northern parts of the basin respectively which indicates the recharge area for groundwater. As the Raipur limestone, capped by laterite and outcropping at higher altitude, forms recharge area, they are responsible for the development of such groundwater mounds.
FIG. 47 PREMONSOON WATER LEVEL MAP OF JAMUNIA RIVER BASIN.
FIG. 48 POSTMONSOON WATER LEVEL MAP OF JAMUNIA RIVER BASIN
4.3.2 **Post-Monsoon**: The water level map of post-monsoon period is roughly similar to that of the pre-monsoon period (Fig. 4.8). There occurs no major variation in contours except the existence of some new groundwater mounds in the vicinity of Suhela, Arjuni and Rawan villages. The development of new groundwater mounds might be either due to the local discharge from deeper aquifer, or have resulted because of heavy pumping as the aquifer is saturated by monsoonal rainwater increasing the water level.

4.4 **DEPTH TO WATER LEVEL MAPS**:

As explained earlier, the whole drainage system is occupied by limestone topography of variable thickness of soil and lateritic overburden. Thus, the groundwater level varies from place to place.

4.4.1 **Pre-monsoon**: In the pre-monsoon period the depth to water level varies generally between 4.7 to 14.5m below the ground level (b.g.l) (Fig. 4.9). The well inventory of openwells has made it possible to divide the basin into three distinct zones.

1. Shallow water level zone with contour of less than 9m bgl.

2. Moderately deep water level zone (9-12m bgl).

3. Deep water level zone (over 12m bgl).

Depth to water level is greater in the southern part of the basin i.e. around Tilda, Chicholi and Tohra villages, and also in the close vicinity of river courses. While other areas show the decreasing trend in water level. Such variations in the water level are mainly contributed by major fracture pattern and extent
FIG 4.9  PREMONSOON [DEPTH TO WATER LEVEL MAP]
of zone of saturation which suggest the variations in permeability and infiltration capacity of the formation. The basin under study is marked by closely spaced contours around a group of wells, except in the eastern part of the basin (Fig. 4.9), which indicates the zone of groundwater discharge (Todd, 1980). The presence of quick recharging and discharging in the Jamunia river basin might be attributed to the wide spread occurrence of limestone and laterite, which possess secondary porosity and infiltration capacity. The eastern part of the basin is largely occupied by shaley limestones which are easily erodible and have lesser degree of secondary openings, resulting in the lack of any groundwater recharge/discharge zones.

4.4.2 Post-monsoon: In the post-monsoon period, depth to water level ranges in between 2 to 5m, below ground level (Fig. 4.10). The trend is roughly same as for pre-monsoon period but the contours are slightly flattened. As the sub-surface formations are saturated with water in rainy season, the water level rises due to infiltration and the depth to water level is decreased.

4.5 GROUND WATER LEVEL FLUCTUATION:

The fluctuation of subsurface water level is directly related to the groundwater recharge and discharge of an area. The rainfall is the principal source of groundwater fluctuation. The groundwater fluctuation has been estimated on the basis of difference in the water levels measured during pre- and post-monsoon periods (Fig. 4.11, and Table- 4.1).
FIG 4.10 POSTMONSOON DEPTH TO WATER LEVEL MAP OF JAMUNIA RIVER BASIN
FIG 4.11 WATER LEVEL FLUCTUATION MAP OF JAMUNIA RIVER BASIN.
Table 4.1: Water Level Fluctuation:

<table>
<thead>
<tr>
<th>Fluctuation in (m.)</th>
<th>Stromatolitic limestones</th>
<th>Dolomitic limestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1.1 (Sararidih)</td>
<td>2.2 (Nakti)</td>
</tr>
<tr>
<td>Maximum</td>
<td>12.5 (Neora)</td>
<td>7.5 (Khapradih)</td>
</tr>
</tbody>
</table>

The groundwater fluctuation map of the basin reveals that the fluctuation is minimum (1.1m) in stromatolitic limestone at Sararidih and 2.2m in dolomitic limestone at Nakti. The maximum groundwater fluctuation of 12.5m is noticed in the Neora village (Appendix-2).

It is observed that in the southwestern part of the basin, the fluctuation is maximum. The fluctuation range of 5.2 to 12.5m is observed in Tilda, Tulsi, Chicholi and Bhimbhori villages which are referred as high fluctuation zones, whereas the remaining parts of the basin indicate relatively less fluctuation zones (1.1 to 5.2m).

In the limestone country, a non-uniform pattern of water level fluctuation has been observed which might be due to the irregular concentration of calcareous and argillaceous sediments present in the area.

4.6 GROUNDWATER RECHARGE AND DISCHARGE ZONES:

The sedimentary pediplain chiefly composed of carbonate rocks shows extensive development of secondary porosity due to
fracture and solutional effects. Groundwater by way of infiltration gets stored in weathered and fractured zones and further moves downward under the favourable conditions.

The detailed analysis of water table contour maps combined with field observations reveals that the south west portion of basin shows higher altitude of watertable, where Raipur limestone capped by laterite represents the recharge area for groundwater. Thus, the area around Chicholi, Bhimbhori, Neora, Kathia and Kumhari villages are the prominent recharge zones. The Jamunia water course is principally controlled by jointing and lineament patterns. Thus, the main stream section from Tilda village to terminal point is suitable groundwater recharge zone. On the contrary, the Banjari nala flows over calc-argillaceous sediments devoid of major fracture systems. The groundwater recharge zones around Pendri, Kuthraud, Ameri and Chandi villages are confined to minor partings and fracture patterns of shaley limestones which permit percolation of groundwater through its bedding planes to a limited depth only. The Mahanadi irrigation canal and Kumhari irrigation canal also contribute to the enrichment of the groundwater body to the area.

Further, the watertable maps show that the general hydraulic gradient is from SW to NE representing that the discharge area of the groundwater are lies to the northern part of the basin. The stream seepages are also responsible for the discharge of groundwater which have been observed in the nala section.